



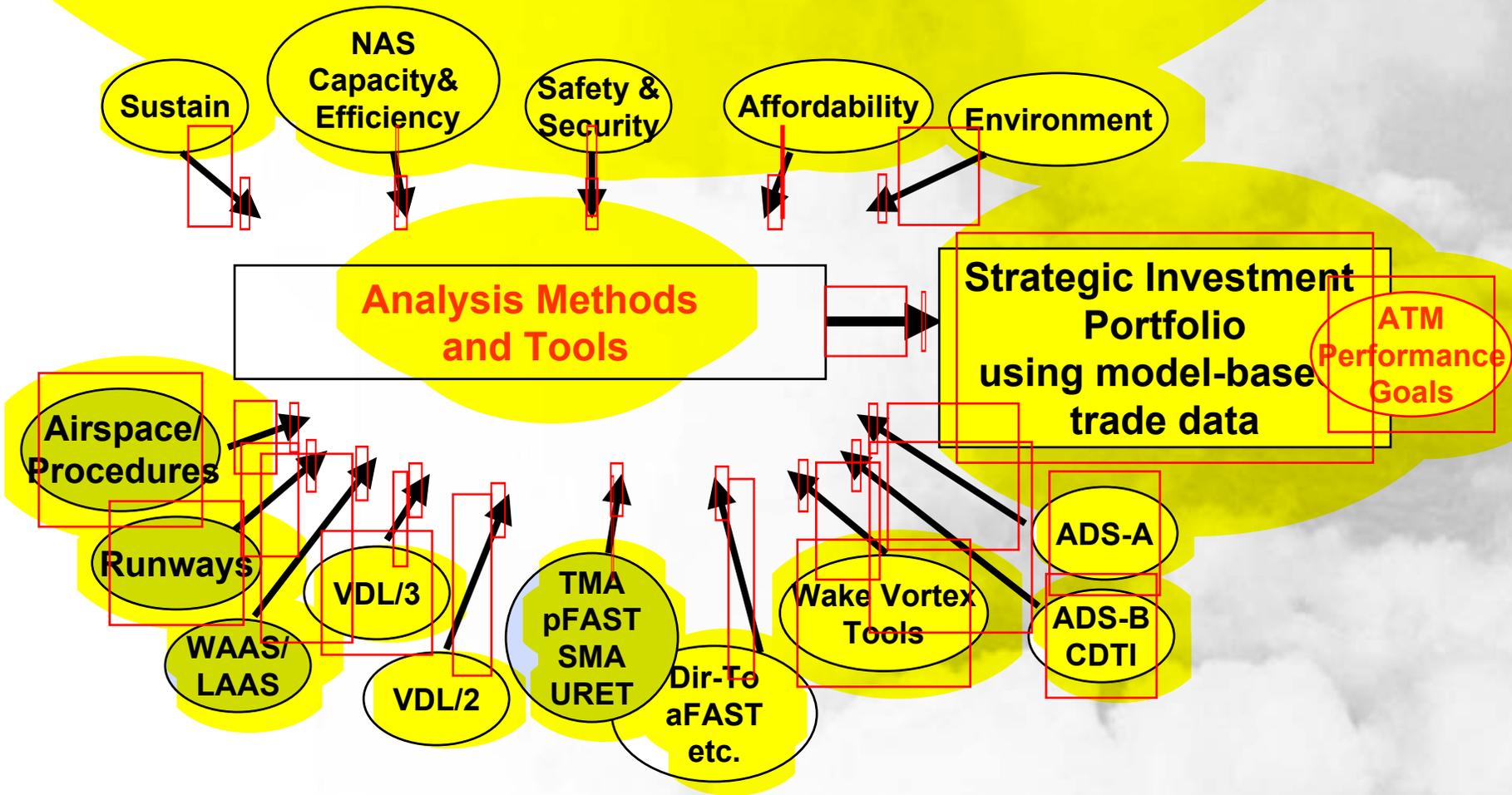
En Route Modeling Workshop 
FAA Free Flight Office

Boeing ATM **Airspace Preliminary Design** **Tools**

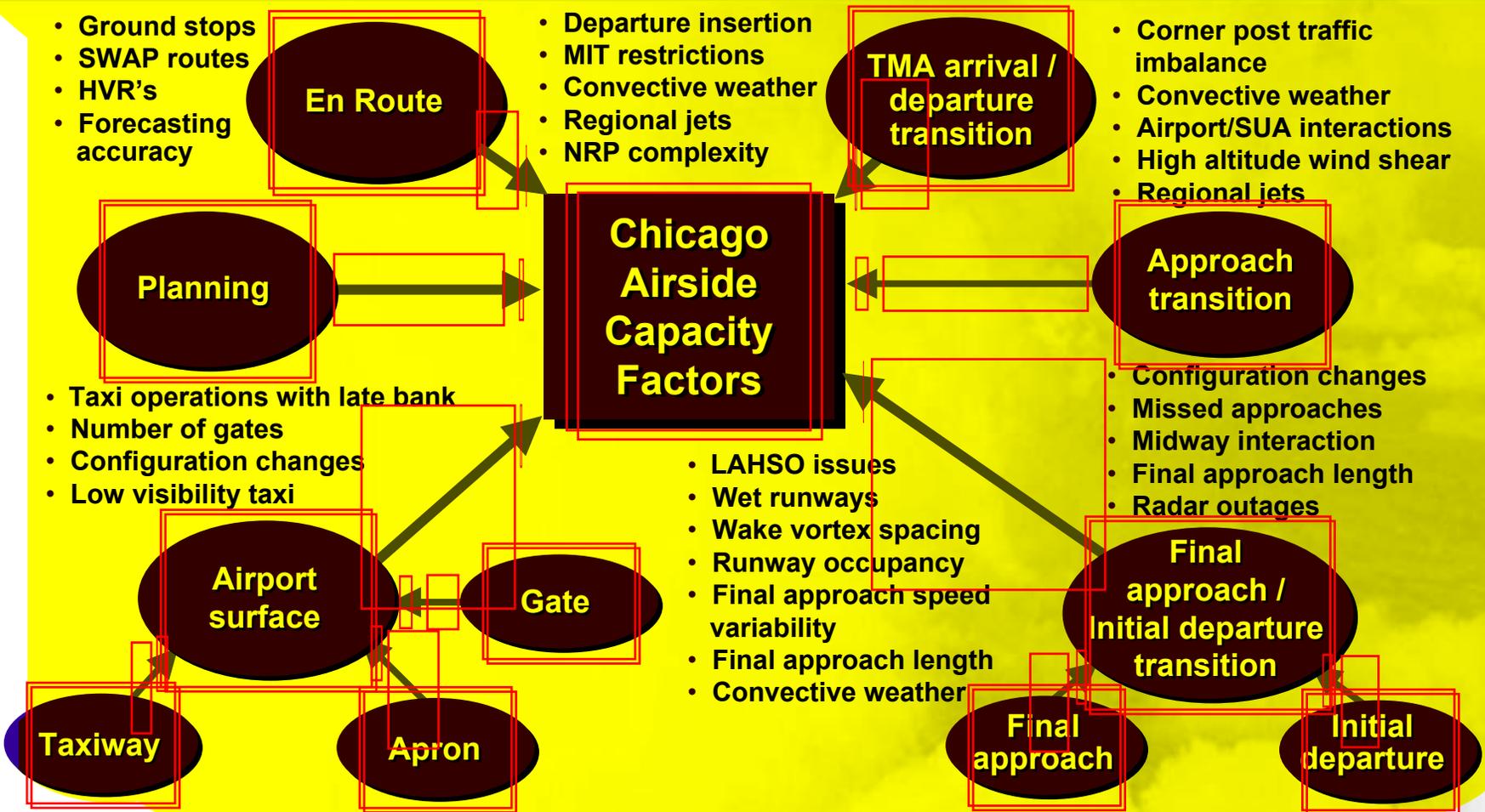
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12 March 2003

CNS/ATM strategic investment problem



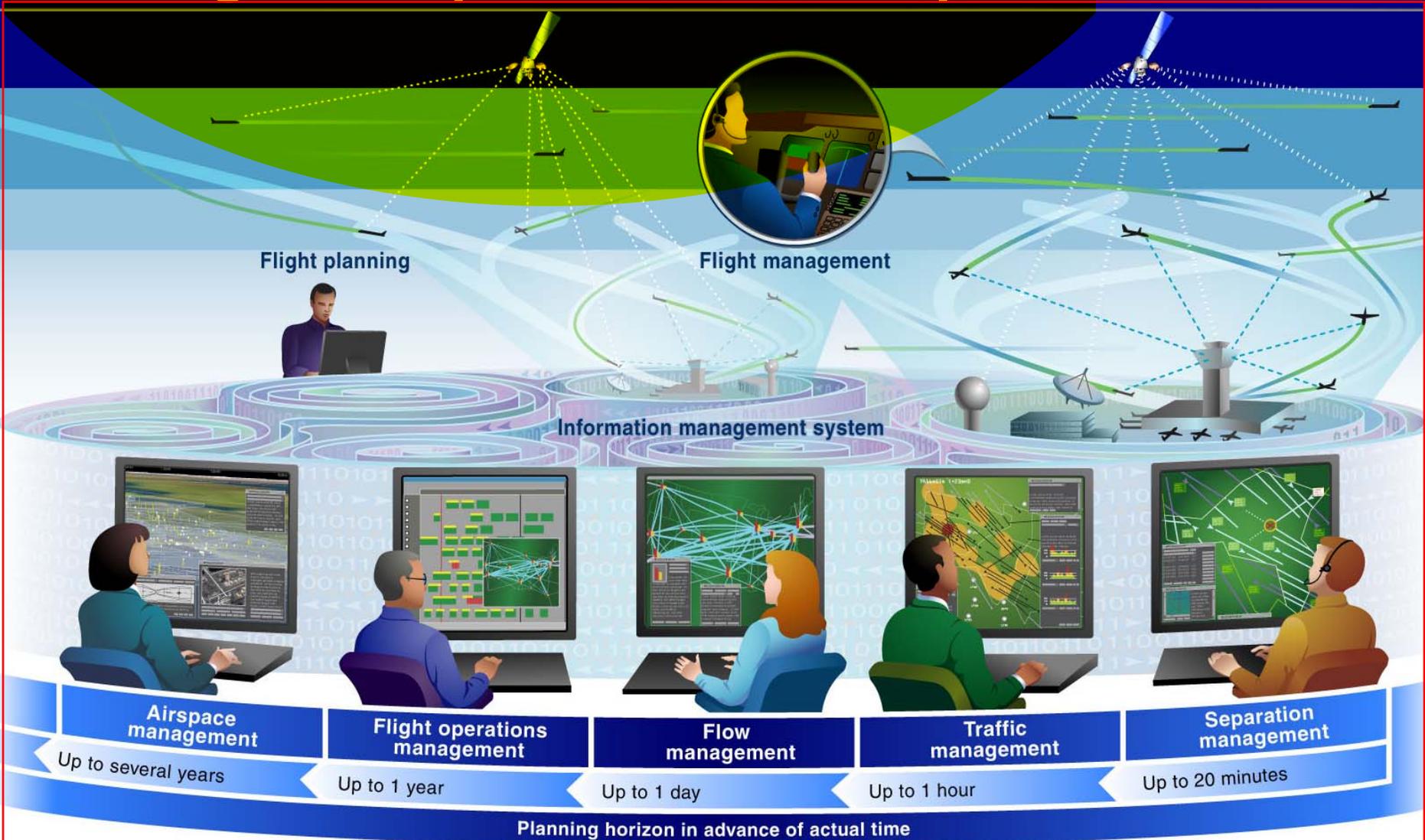
Operational issues – Case study capacity factors



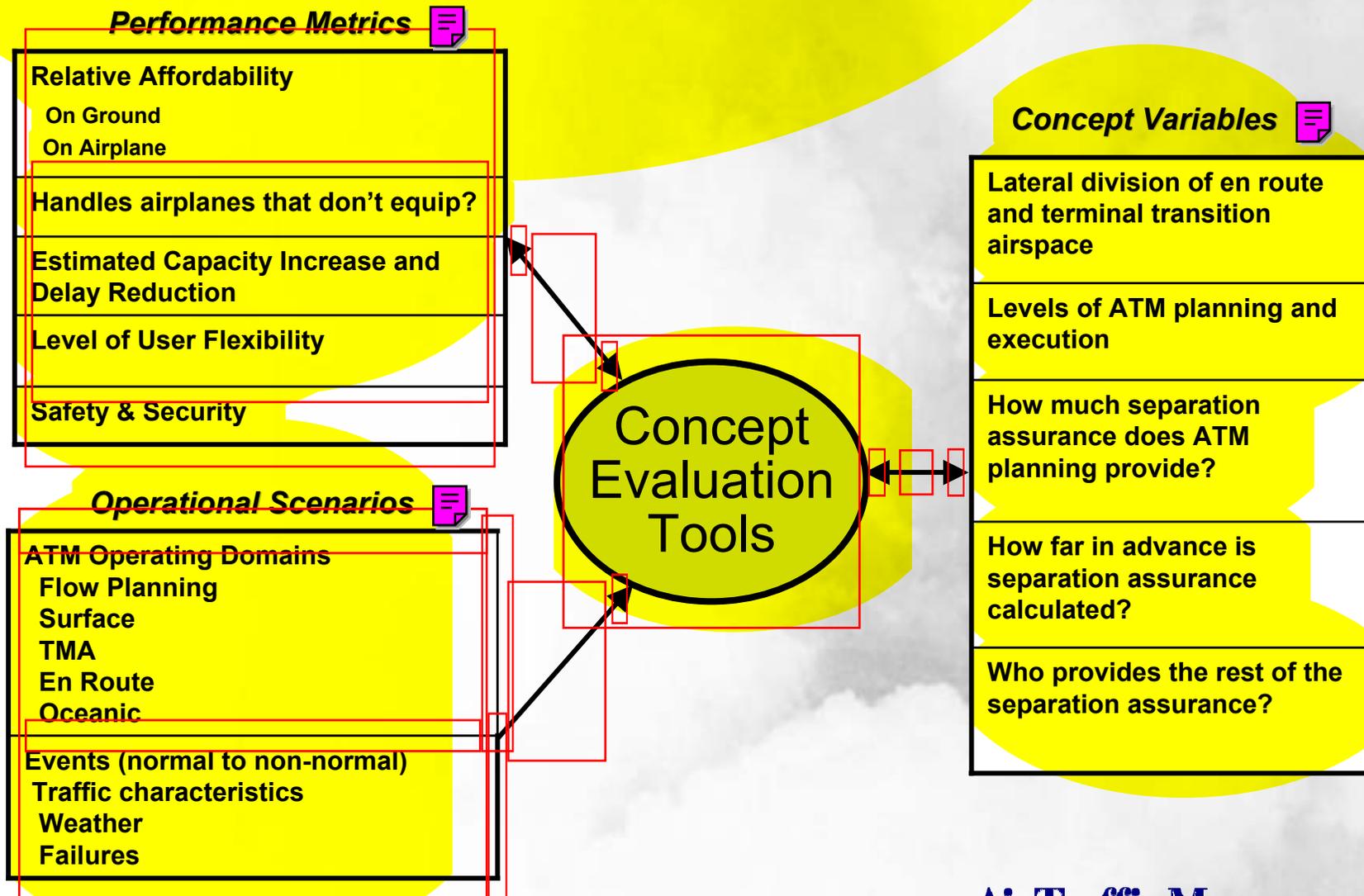
• **Complex, inter-acting constraints dynamically change airport and airspace capacities**

Source: NASA Sponsored Airspace Preliminary Design Case Study

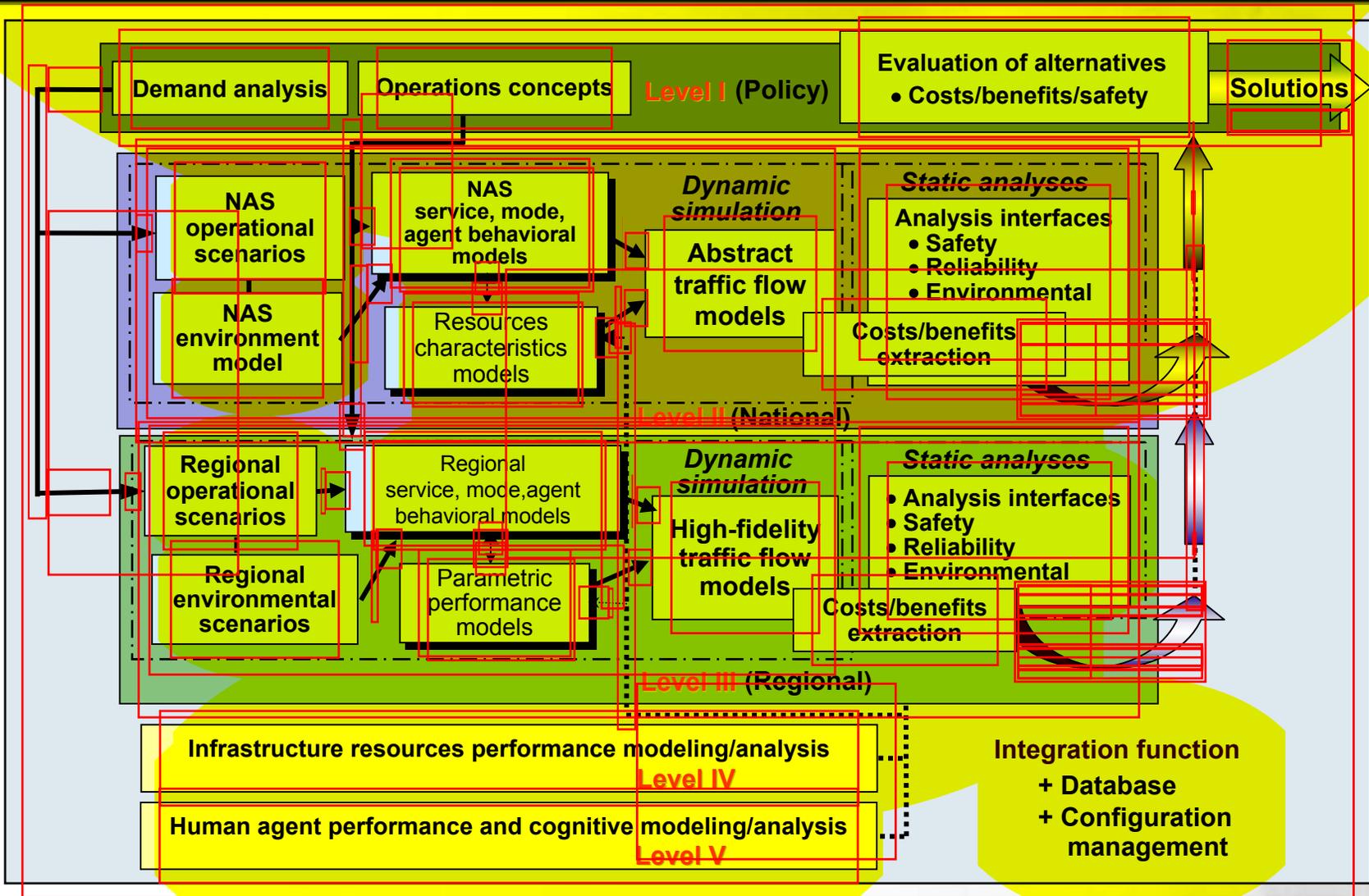
Boeing ATM operational concept



Operational concept trade space



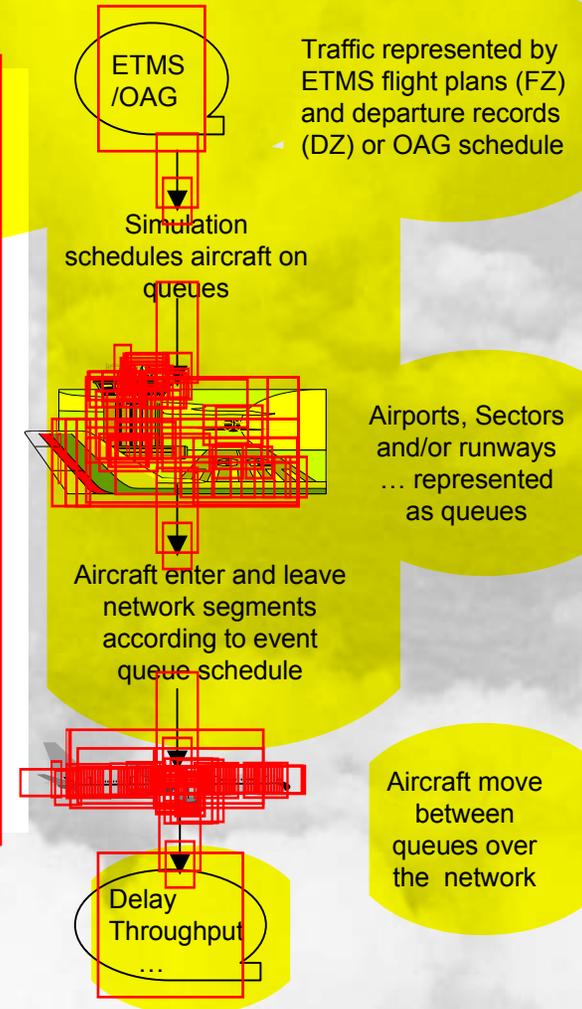
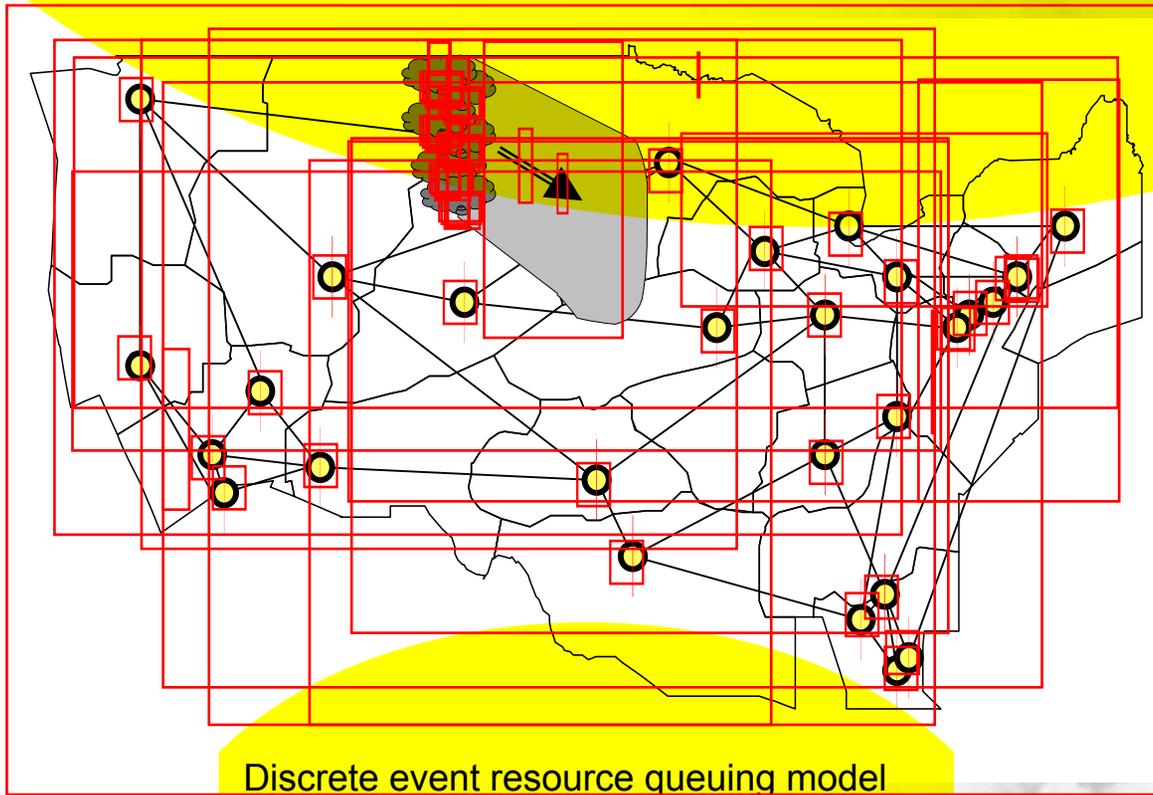
An integrated airspace simulation tool set



PD toolset – modeling hierarchy and fidelity

	Time Horizon	Modeled Airspace	Model Detail / Type of Simulation Model
Level II: National Flow Model (NFM)	Up to 30 Hours NAS Simulation;	National Airspace	<ul style="list-style-type: none"> Resource Queuing Models Air Routes are Capacity-Constrained Links Airports and Sectors are Capacity-Constrained Nodes Inclusion of Resource Queuing Models for Delay Analysis Pure Discrete Event Model
Level III: Regional Traffic Model (RTM)	Up to 60 Minutes	Multi- Sector Airspace	<ul style="list-style-type: none"> Dynamic Aircraft Models Human Task Models for Controllers & Pilots Models of Airports, Airspace and ATC / ATM/ CNS Infrastructure Elements Mixed Continuous Time / Discrete Event Model (Hybrid Model)
Level IV: Infrastructure Performance Model	Same as Regional Model	Same as Regional Model	<ul style="list-style-type: none"> Same as Regional Model plus Higher Fidelity Model for Infrastructure Elements
Level V: Human Agent Performance Model	Same as Regional Model	Same as Regional Model	<ul style="list-style-type: none"> Same as Regional Model plus Higher Fidelity Human Model for Controller and Pilot

A National Flow Model (NFM) for airspace preliminary design analysis



NFM – areas of investigation

System performance:

- NAS-wide delay reduction/throughput benefits
- NAS-wide impact of capacity increases
- NAS system predictability
- Inputs to technology investment and economic benefits analysis

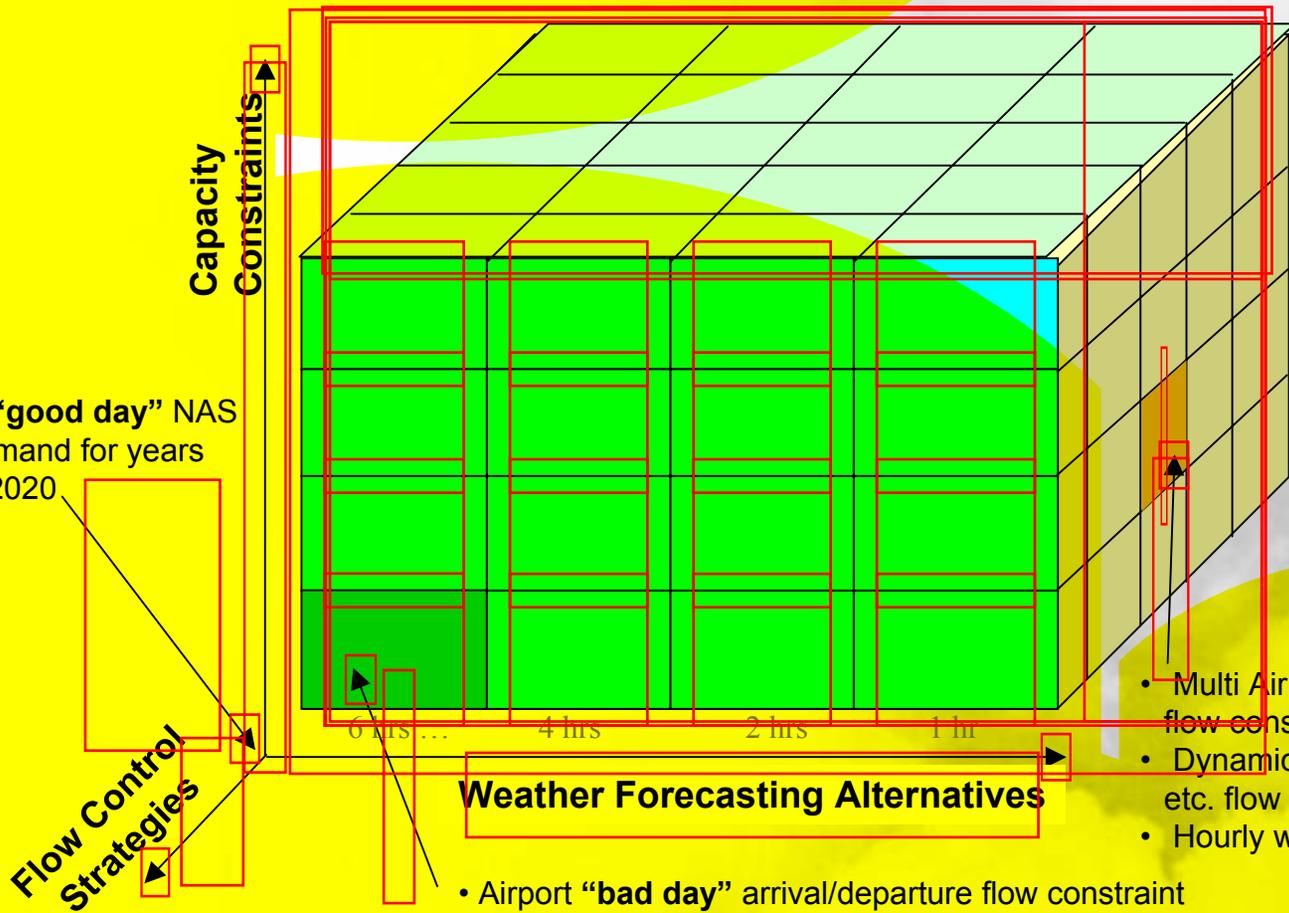
Operations:

- Coordinated flow management and execution
- Convective weather avoidance routing
- Airspace utilization

ATC Infrastructure:

- Traffic Flow Management control strategies
- NAS-wide message/link capacities for communication technologies

NFM study example – Traffic flow problem space



- Baseline “good day” NAS
- Traffic demand for years 2000, ... , 2020

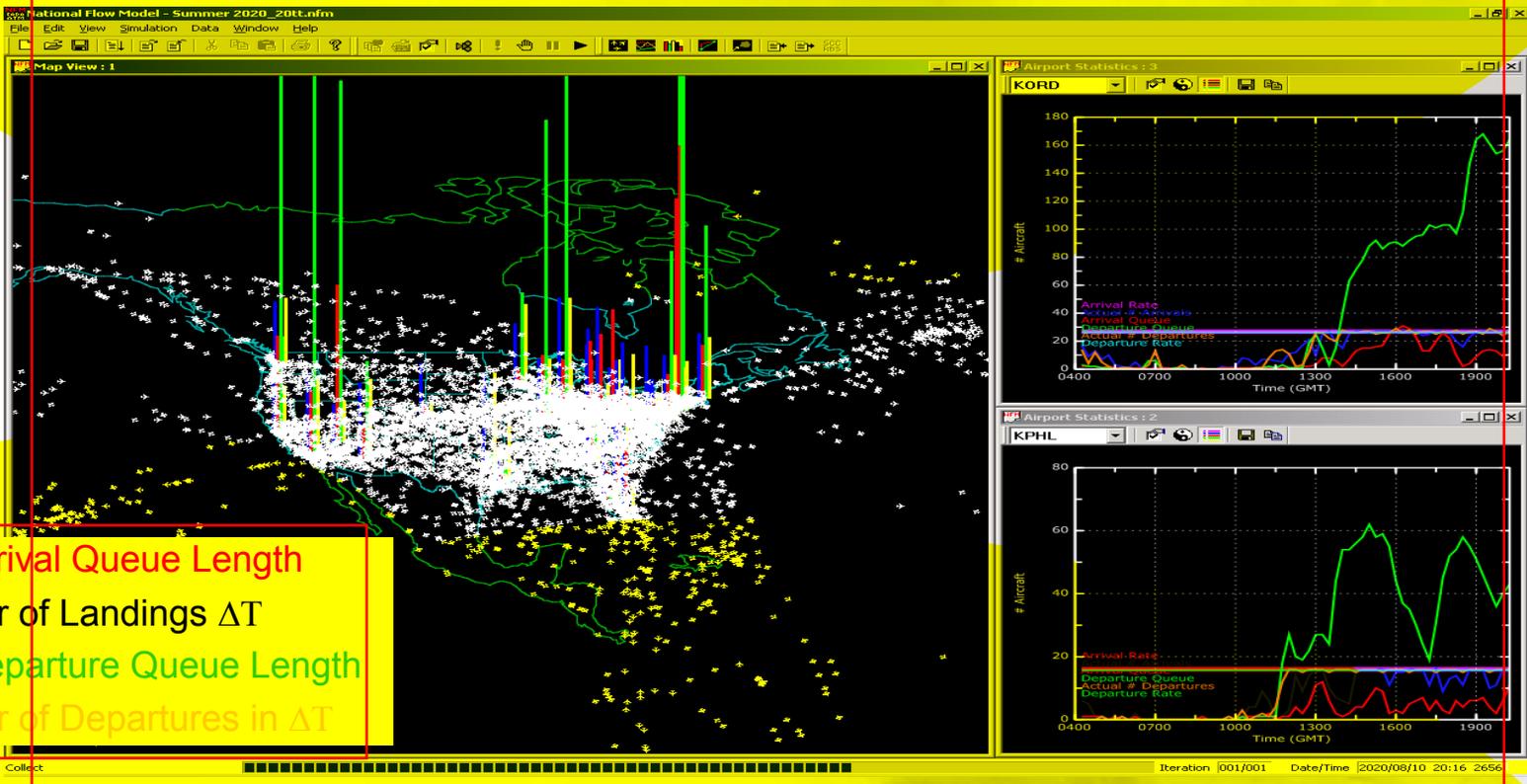
- Multi Airport (Regional) “bad day” flow constraint
- Dynamic re-routing, departure delay, etc. flow strategies (AOC/SCC)
- Hourly weather forecast & updates

Weather Forecasting Alternatives

- Airport “bad day” arrival/departure flow constraint
- Today’s departure holding/delay flow strategy (RBS)
- Today’s weather forecast methods & update processes

Flow Control Strategies

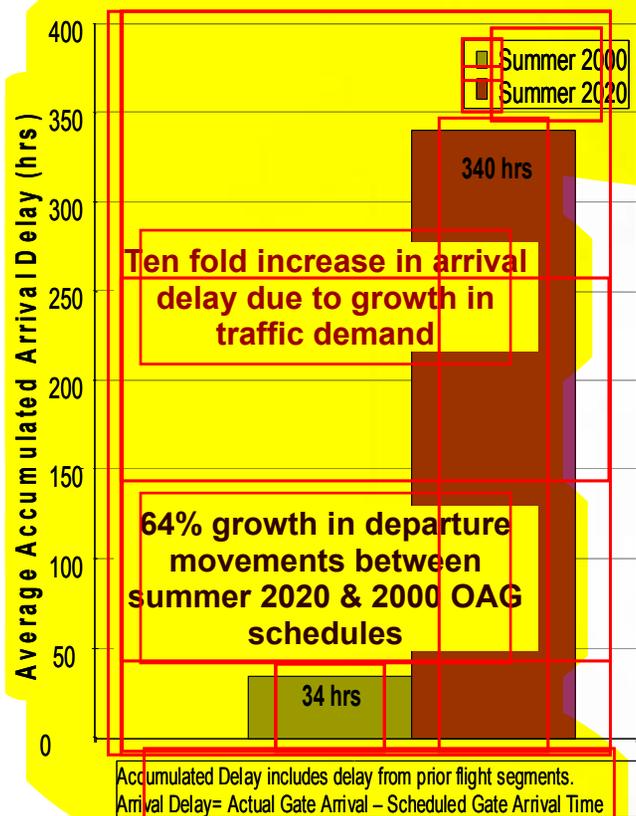
NFM study example – “Good Day” airport congestion in the Summer 2020



- Airports have maximum capacity limits (i.e. FAA Benchmark arrival/departure rates)
- Airport queuing causes airborne arrival delay or taxi delay on departure
- Flow control initiatives cause pre-departure delay to avoid excessive airborne holding

A "Good Day" airport capacity baseline

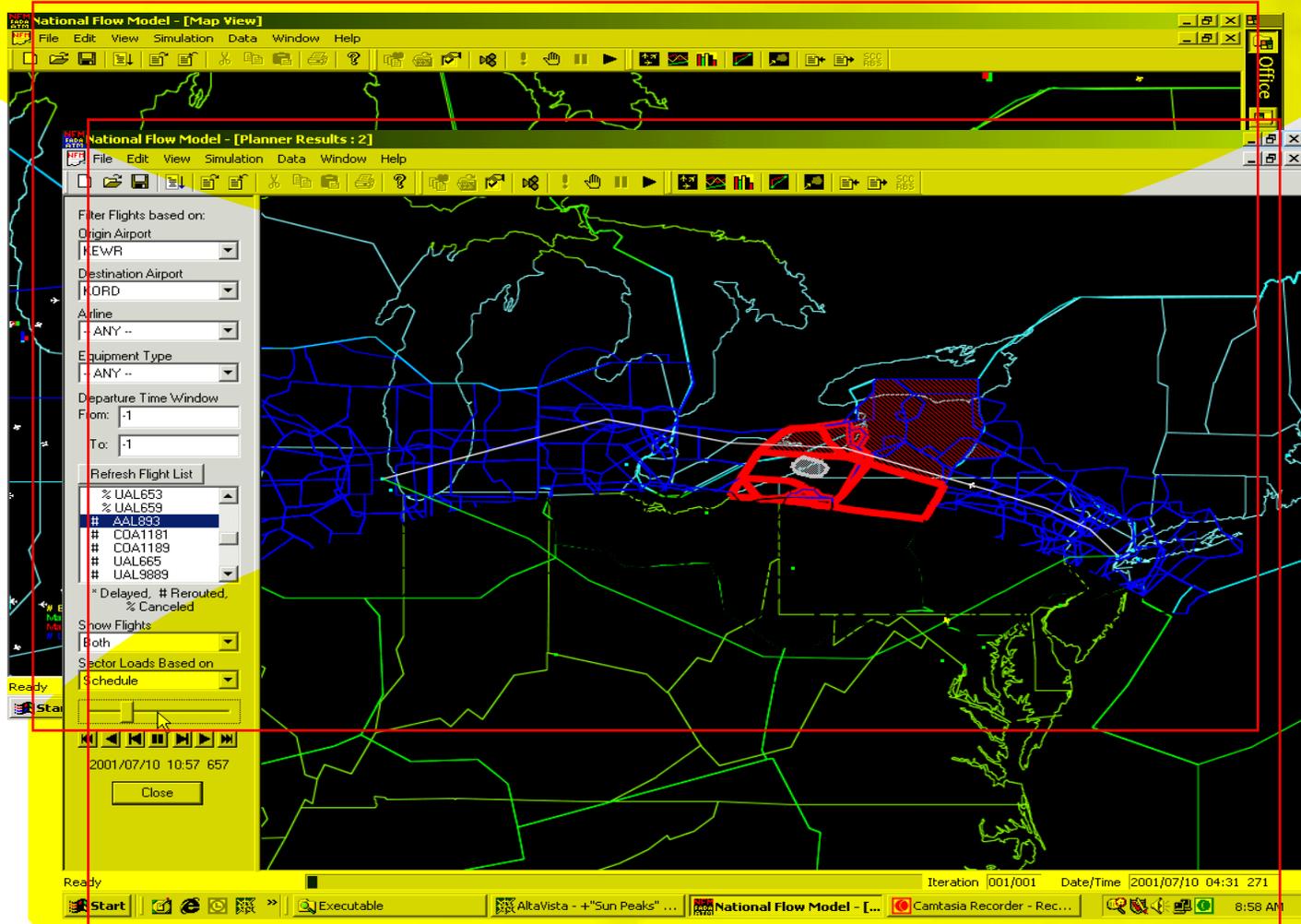
Summer 2020 vs. 2000 traffic – airport delay averaged over 31 FAA benchmarked airports



2020 Traffic Demand Generation Assumptions:

- Single day / US Domestic only, OAG flights only
- 2020 schedule generated to agree with Boeing Commercial Airplanes Current Market Outlook (CMO) forecasts of year 2000
- No new non-stop airport (AP) pairs
- Same airlines, hubs, and banks
- Direct constraint on maximum number of operations at each airport in any given 5 minute time period
- New schedule for hub-spoke (banked) flights - unbanked operations will be incremental to today's OAG
- Schedule will not be efficiently tail routable

NFM study example – Dynamic re-routing impact on en-route congestion





Summary

- The preliminary design tool set fills the gap between top-level economic evaluation and costly human-in-the-loop simulations
- The NFM simulation enables quantifiable analysis of NAS-wide flow interactions at the network level (5-6K peak a/c counts, 50-60K a/c in a schedule); it is developed to represent current and future traffic flow strategies
- NFM serves as a test bed for evaluation and development of new ATM operational concepts, system architectures and benefits assessments
- NFM analysis derives requirements for operational product development

Ability to tap into the inner behaviors of the NAS in fast-time, provides quantifiable data crucial to the large-scale 'imagineering' of tomorrow

For more information, please visit our web site

<http://www.boeing.com/atm>

